Abstract

Predicting on circular domains with Gaussian processes

O. Roustant, joint work with E. Padonou

This research was motivated by two industrial problems in microelectronics and environment, where one has to reconstruct a spatial variable on a disk from a few number of experiments. In this context Gaussian process (GP) regression, or Kriging, is often used, sometimes coupled with Zernike polynomials which are orthogonal polynomials on the disk. However, usual GP models do not take into account the geometry of the disk in their covariance structure (or kernel), which may be a drawback at least for technological or physical processes involving a diffusion from the center of the disk, or a rotation. In this talk we introduce so-called polar GPs, defined on the space of polar coordinates. Their kernels are obtained by algebraically combining kernels on [0,1] and on the circle. Their efficiency is illustrated on the two applications, where radial and angular patterns are visible.

In a second time, we consider the design of experiments (DoE) issue for polar GPs. We show how to adapt the construction of optimal space-filling designs for polar coordinates. Two new DoEs are introduced and compared to the D-optimal designs for Zernike polynomials. Their efficiency in prediction is also assessed on a set of various toy functions and models.

Keywords:
Circular domains, Disk, Circle, Directional data,
Gaussian process regression, Kriging, Zernike polynomials,
Design of Experiments.